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None

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(54) Abstract Title
Communications apparatus and method of communicating timing information

(57) In communication systems requiring timing data, it is sometimes desirable to provide such timing data over an asynchronous medium, for example, Ethernet. However, it is understood that such timing data cannot be transmitted via the Ethernet. The present invention provides a mechanism for inserting timing information in an inter-frame gap (502) of a data frame (500) of the Ethernet. Consequently, it is possible to transmit timing information via the Ethernet. The provision of timing data in the inter-frame gap (502) obviates the need for a dedicated connection between network entities (206, 208) coupled to the Ethernet.

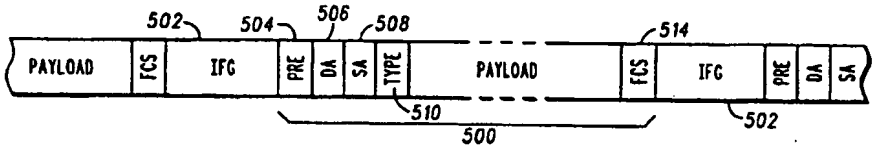

FIG. 5

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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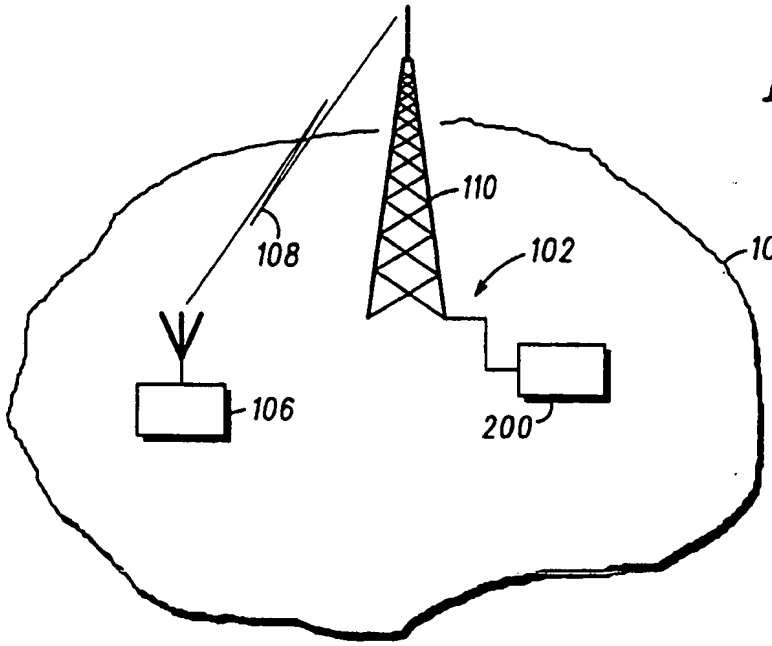


FIG. 1

100

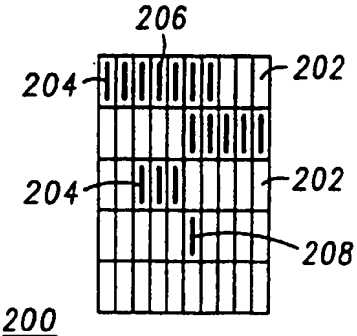
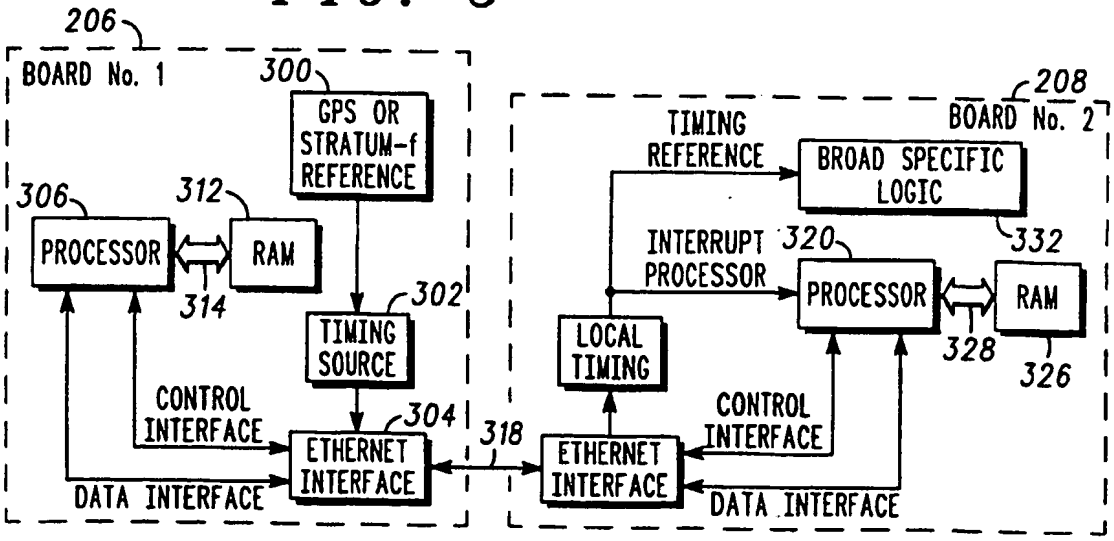


FIG. 2

200

FIG. 3



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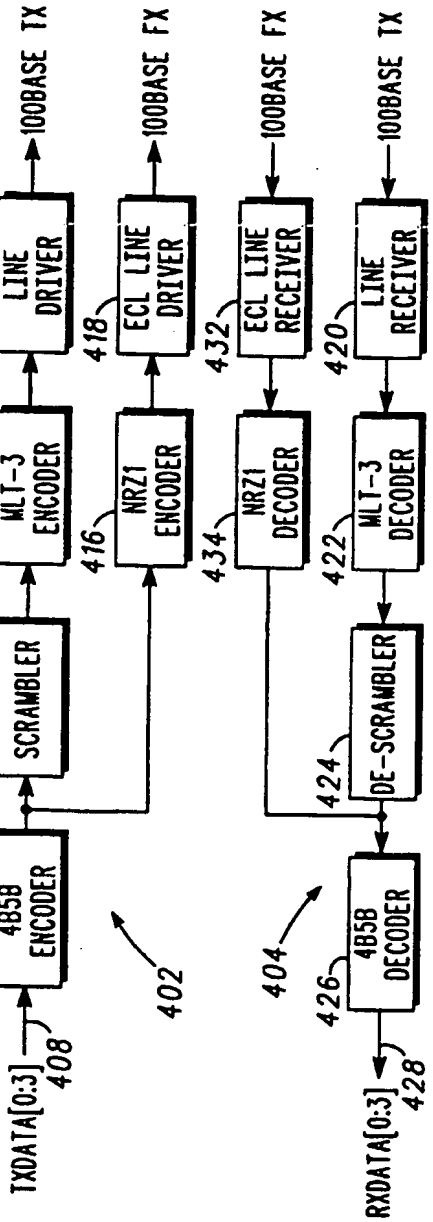

FIG. 4

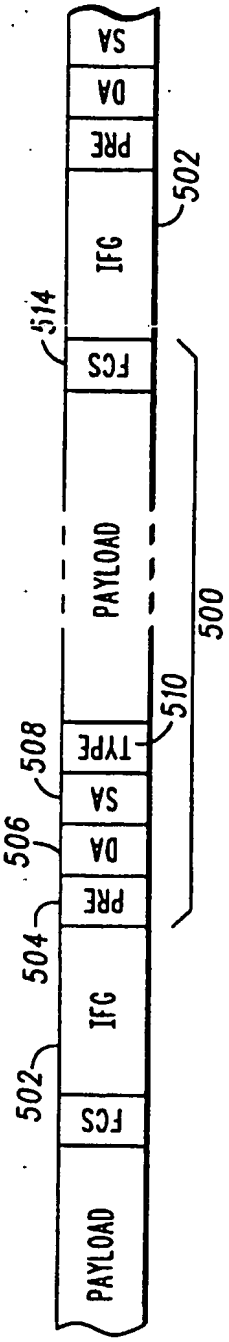

FIG. 5

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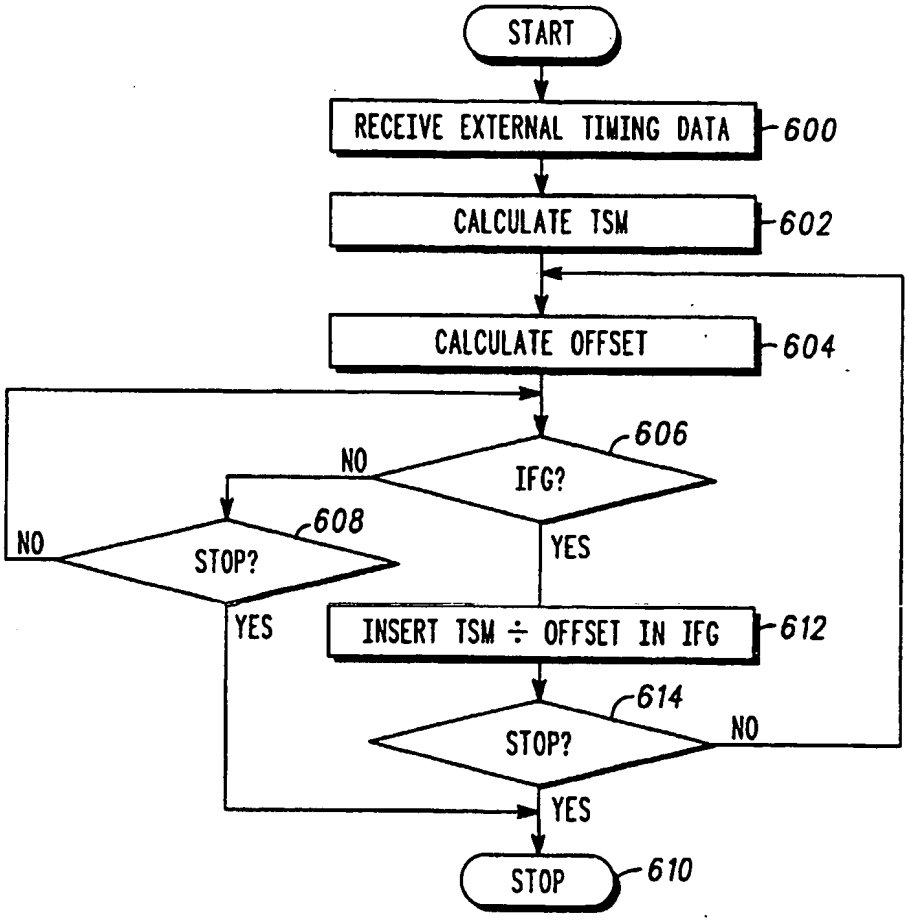
START
RECEIVE EXTERNAL TIMING DATA
600
CALCULATE TSM
602
CALCULATE OFFSET
604
606
IFG?
NO
YES
608
STOP?
NO
YES
INSERT TSM ÷ OFFSET IN IFG
612
614
STOP?
NO
YES
STOP
610

FIG. 6

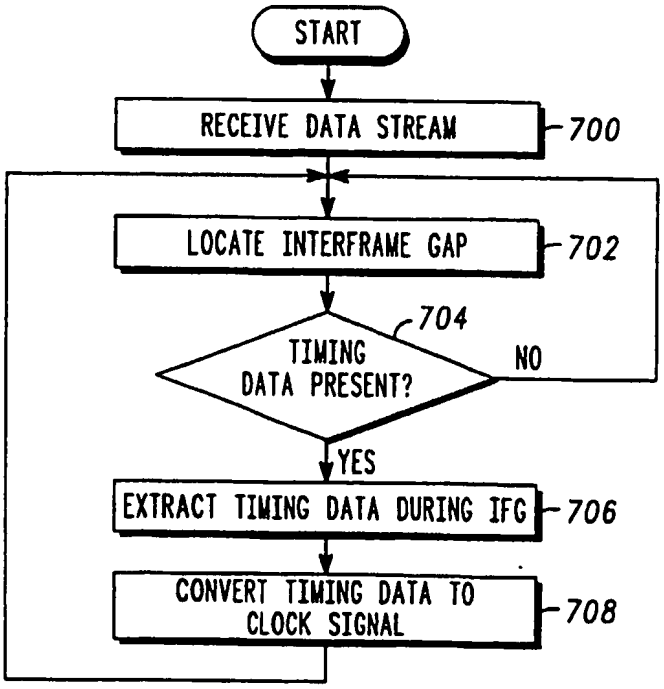
START
RECEIVE DATA STREAM
700
LOCATE INTERFRAME GAP
702
704
TIMING DATA PRESENT?
NO
YES
EXTRACT TIMING DATA DURING IFG
706
CONVERT TIMING DATA TO CLOCK SIGNAL
708

FIG. 7

COMMUNICATIONS APPARATUS AND METHOD OF COMMUNICATING TIMING INFORMATION

Field of the Invention

The present invention relates to a communications apparatus comprising a first network entity and a second network entity interconnected by an Ethernet, such as a base station in a cellular communications network. The present invention also relates to a method of communicating timing information in an Ethernet between a first network entity and a second network entity, for example, a first card and a second card in the communications apparatus.

Background of the Invention

In a Global Positioning Satellite (GPS) system, each satellite in the system comprises a very accurate clock. The clock is accessible by a suitable GPS receiver and is commonly used to synchronise base stations of communications systems typically for voice applications. The base stations obtain timing information constituting Universal Time Co-ordinates (UTC). UTC is an internationally agreed time standard for providing an absolute reference frame for measuring time, for example, a regular 1s clock signal, occurring at precisely the same time in all UTC-aligned clocks. A number of UTC-aligned clocks is known as a Stratum-1 reference.

In the case of an in-building radiocommunications cell, for example, a pico-cell supported by a Global System for Mobile Communications (GSM) base station, a dedicated land-line would be required to communicate the UTC to the pico-cell base station. If th building in which the pico-cell base station is located is equipped with an Ethernet that interfaces with a pre-installed land-line, it is desirable to communicate the UTC from the pre-installed land-line to the pico-

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cell base station via the Ethernet. However, although the Ethernet embeds a clock signal into a data stream as a reference signal to drive counters, the clock signal is free running and so does not automatically carry a time-sync 'marker' required to indicate locations of a regular, for example, 1s reference marker provided by the land-line.

Similarly, in a rack comprising a plurality of cards, for example a rack constituting a GSM base station, it is desirable to connect each GSM card to a switching card using an Ethernet in order to transfer traffic between the cards. However, due to the synchronous nature of GSM, it is necessary to use a separate connection, in addition to the Ethernet connection, between each GSM card and the switching card in order to communicate timing information between the GSM cards, because, as mentioned above, the Ethernet is asynchronous in nature.

Summary of the Invention

According to a first aspect of the present invention, there is provided a method of communicating timing information in an Ethernet between a first network entity and a second network entity coupled, the method comprising the steps of communicating a plurality of frames of data between the first network entity and the second network entity, at least two of the plurality of frames of data being separated by an inter-frame gap, and characterised by communicating timing information in the inter-frame gap between the first network entity and the second network entity.

Preferably, the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

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Preferably, the predetermined amount of the timing signal is a period of the timing signal.

Preferably, the offset data corresponds to a number of timing units.

More preferably, the timing units are clock signals.

According to a second aspect of the present invention, there is provided a communications apparatus comprising an Ethernet coupled to a first network entity and a second network entity, the first network entity and the second network entity being arranged to communicate a pluraiity of frames of data therebetween, at least two of the plurality of frames of data being separat d by an inter-frame gap, characterised in that wherein the first network entity and the second network entity are adapted to communicate timing information therebetween in the inter-frame gap.

Preferably, the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

Preferably, the predetermined amount of the timing signal is a period of the timing signal.

Preferably, the offset data corresponds to a number of timing units.

More preferably, the timing units are clock signals.

The above described communications apparatus may be provided in a base station.

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According to a third aspect of the present invention, there is provided a network entity apparatus for coupling to an Ethernet, the apparatus comprising: a transmitter coupled to a processing unit and arranged to transmit a plurality of frames of data, at least two of the plurality of frames of data being separated by an inter-frame gap, characterised in that wherein the processing unit is arranged to insert timing information in the inter-frame gap for transmission by the transmitter.

According to a fourth aspect of the present invention, there is provided a network entity apparatus for coupling to an Ethernet, the apparatus comprising: a receiver coupled to a processing unit and arranged to receive a plurality of frames of data, at least two of the plurality of frames of data being separated by an inter-frame gap, characterised in that wherein the processing unit is arranged to extract timing information from the inter-frame gap.

Preferably, the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

Preferably, the predetermined amount of the timing signal is a period of the timing signal.

Preferably, the offset data corresponds to a number of timing units.

More preferably, the timing units are clock signals.

The above described network entity apparatus may be provided in a base station.

According to a fifth aspect of the present invention, there is provided a communication signal for an Ethernet, the signal corresponding to a first frame

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(500) of data separated from a second frame of data by an inter-frame gap (502), characterised in that wherein the inter-frame gap (502) comprises timing information.

Preferably, the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

Preferably, the predetermined amount of the timing signal is a period of the timing signal.

Preferably, the offset data corresponds to a number of timing units.

More preferably, the timing units are clock signals.

According to a sixth aspect of the present invention, there is provided a computer program element comprising computer program code means to make a computer execute the method as described above. The computer program element may be embodied on or in a computer readable medium.

According to a seventh aspect of the present invention, there is provided a use for a code set to communicate timing information between a first network entity and a second network entity coupled to an Ethernet, the first network entity and the second network entity being arranged to communicate a plurality of data frames therebetween, at least two of the plurality of data frames being separated by an inter-frame gap, characterised in that wherein at least one symbol of the code set is communicated in the inter-frame gap, the at least one symbol corresponding to the timing information.

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Preferably, the at least one symbol of the code set comprises an offset symbol indicative of a point in time corresponding to a predetermined amount of a timing signal.

Preferably, the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

Preferably, the offset symbol corresponds to a number of timing units.

More preferably, the timing units are clock signals.

Preferably, the code set is a 4B5B code set.

Preferably, the code set is an 8B10B code set.

In a preferred embodiment of the invention, there is provided a base station comprising an Ethernet coupled to a first communications card and a second communications card, the first communications card and the second communications card being interconnected to communicate a plurality of frames of data therebetween, at least two of the plurality of frames of data being separated by an inter-frame gap, wherein the first communications card and the second communications card are adapted to communicate timing information in the form of offset data indicative of a point in time corresponding to a period of a timing signal, the timing information being communicated between the first communications card and the second communications card in the inter-frame gap.

It is thus possible to provide a communications apparatus and a method for communicating timing information without the need for a dedicated connection to provid timing information.

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Brief Description of the Drawings

At least one embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a communications cell;

Figure 2 is a schematic diagram of a rack constituting an embodiment of the present invention;

Figure 3 is a schematic diagram of an Ethernet connection between two cards in the rack of Figure 2;

Figure 4 is a schematic diagram of a transceiver used in at least one of the cards of Figure 3;

Figure 5 is a schematic diagram of a frame structure used by the Ethernet of Figure 3; and

Figures 6 and 7 are flow diagrams of the communication of timing information by the apparatus of Figures 1 to 5.

Description of a Preferred Embodiment

Throughout the description, identical reference numerals will be used to identify like parts.

In a communications system 100, for example a GSM, there is provided a base station 102 supporting a cell 104. The base station 102 is capable of communicating with a terminal, for example, a mobile terminal 106, via a Radio Frequency (RF) interface 108. Although reference has been made above to the GSM above, it should be appreciated that the pres nt invention is not limited to GSMs and can be applied to other communication systems including Universal Mobile T lecommunications Systems (UMTSs) and TETRA systems.

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The base station 102 comprises an antenna 110 coupled to a rack 200. The rack 200 comprises a plurality of slots 202 into which network cards 204 are inserted. The network cards 204 are interconnected in the rack 200 by an Ethernet, each of the network cards 204 providing a predetermined functionality to enable the rack 200 to process signals received in accordance with the GSM standard.

A first card 206 is capable of communicating with a second card 208 in the rack 200 by means of an Ethernet connection (not shown). Referring to Figure 3, the first card 206 provides a UTC (not shown) based upon a GPS or Stratum-1 reference signal 300. The GPS or Stratum-1 reference signal 300 is used by a timing source unit 302 to generate the UTC for use by a first Ethernet interface unit 304. Data and control signals are communicated to the first Ethernet interface unit 304 from a processor 306 via a first data bus 308 and a first control bus 310, respectively. The processor 306 is coupled to a first volatile memory unit, for example, a first Random Access Memory (RAM) 312 through a first memory data bus 314.

The first Ethernet interface unit 304 is coupled to a second Ethernet interface unit 316 located on the second card 208 via an Ethernet link 318, for example, a twisted pair cable. Of course, it should be appreciated that, depending upon the type of Ethernet being employed, the Ethernet link 318 can be formed from a different connecting medium, for example, a fibre-optic cable.

The second Ethernet interface unit 316 is coupled to a second processor 320 via a second data bus 322 and a second control bus 324. The second processor 320 is coupled to a second non-volatile memory unit, for example, a second RAM 326 via a second memory data bus 328.

The second Ethernet interface unit 316 is also coupled to a local timing unit 330, the local timing unit 330 being coupled to the second processor 320 and board specific logic 332. For the purposes of simplicity and clarity of description, the board specific logic 332 will not be described in any further detail. However, it should be appreciated that the board specific logic 332 can be any logic to provide functionality in a system, for example, a communications system such as the GSM cellular communication system. It should be appreciated that the present invention is not limited to any particular type of board specific logic.

Each of the first and second Ethernet interface units 304, 316 comprise a 100Mbps Ethernet transceiver. In this respect, each of the Ethernet interface units 304, 316 comprises a transmitter chain 402 and a receiver chain 404. If the Ethernet uses twisted pair cable for connections, the transmitter chain 402 comprises a 4 Bit 5 Bit (4B5B) encoder 406, having an input terminal 408 to receive a datastream (not shown). The 4B5B encoder 406 is coupled to a scrambler unit 410, the scrambler unit 410 being coupled to a Multi-Level Ternary Code (MLT-3) encoder unit 412, the MLT-3 encoder unit 412 being coupled to a line driver 414. The receiver chain 404 comprises a line receiver 420 having an input terminal for receiving an input signal, the line receiver 420 being coupled to an MLT-3 decoder unit 422. The MLT-3 decoder unit 422 is coupled to a descrambler unit 424, the descrambler unit 424 being coupled to a 4B5B decoder unit 426 having an output terminal 428 to provide a datastream (not shown).

If the Ethernet is fibre-optic based, instead of being coupled to the scrambler unit 410, the MLT-3 encoder unit 412 and the line driver 414, the 4B5B encoder 406 of the transmitter chain 402 is coupled to a Non-Return Zero Inv rt (NRZI) encoder unit 416, the NRZI encoder unit 416 being coupled to an

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Emitter-Coupled Logic (ECL) line driver 418. Similarly, the line receiver unit 420, the MLT-3 decoder unit 422 and the descrambler unit 424 of the receiver chain 404 are replaced by an ECL line receiver 430, having an input terminal 432 for receiving the input signal, the ECL line receiver 430 being coupled to an NRZI decoder unit 434. The NRZI decoder unit 434 is coupled to the 4B5B decoder unit 426.

Referring to Figure 5, the Ethernet uses a frame structure 500 preceded by an inter-frame gap (IFG) 502 of 12 octets and comprises a preamble sequence (PRE) 504 of eight octets. The preamble sequence 504 is followed by a destination address (DA) 506 of six octets, the destination address 506 being followed by a source address (SA) 508 of six octets. A type field (TYPE) 510 of two octets follows the source address 508 and is indicative of a type of payload carried by the frame 500. Payload data 512 (PAYLOAD) of at least forty-six octets in length follows the type field 510. The payload data 512 is then followed by a Cyclic Redundance Check (CRC) frame check sequence (FCS) 514 of four octets. The frame 500 is then followed by another frame after another inter-frame gap 502.

The 4B5B encoder unit 406 and the 4B5B decoder unit 426 of the transmitter chain 402 and the receiver chain 404, respectively, embed delimiter markers in the encoded datastream to indicate the start and end of the frame 500. The start and end of the frame does not include the inter-frame gap 502 and the delimiter markers are part of a code set conforming to the Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE 802.3-1998. For example, a Start of Stream Delimiter (SSD) is represented by the symbols J+K in accordance with the above IEEE standard and correspond to the bit pattern 11000 10001. Similarly, an End of Stream Delimiter (ESD) is represented by the predefined symbols T+R corresponding to the bit pattern 01101 00111.

In order to communicate timing information between the first and second cards 206, 208, unassigned symbols/codes from the 4B5B code set are used to provide an indication of timing in the form of a Time Sync Marker (TSM) during the inter-frame gap 502, optionally, in every inter-frame gap 502. Therefore, for example, the TSM is represented by the unassigned codes V+R corresponding to the bit pattern 11001 00111.

Since the timing of the inter-frame gap 502 cannot be guaranteed to match the time when a TSM needs to be sent, the TSM is accompanied by an offset count to indicate a point in time, a number of clock cycles subsequent to the TSM, corresponding to a pulse of a timing signal, for example, the UTC. The clock cycles subsequent to the TSM are derived from an Ethernet clock signal (not shown), the first clock pulse beginning after the last bit of the TSM. Consequently, it is possible to embed a frame sink signal, for example, a 125 s frame marker conforming to the T1/E1 plesiochronous digital hierarchy or a one second GPS/UTC marker in the datastream.

The marker therefore consists of a TSM plus four symbols (from the symbols set values 0 to F) representing an offset in hexadecimal of up to 65536 clock cycles. The hexadecimal offset of up to 65536 clock cycles is sufficient for operation with most frame sizes. However, where larger (jumbo) frames of around 9000 octets are used, the counter decrement clock rate needs to be halved. The TSM marker plus four symbols occupies 30 out of the 96 bits of the inter-frame gap 302.

In order to avoid an error, it is necessary for the first Ethernet interface unit 304 and the second Ethernet unit 316 to ignore the reserved "V" (Code 31) symbol, because the reserved 'V' symbol is normally interpreted as an "error on the line" and this error symbol must be ignored in order for the Ethernet to operate correctly. Additionally, the first and second Ethernet interface units

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304, 316 need to negotiate whether the offset is counted using the line-clock or the line-clock/2. These functions are made possible using "technology ability extension" facilities provided by IEEE 802.3-1998 "Next page" link auto-negotiation.

Although in the above examples, the first Ethernet interface unit 304 and the second Ethernet interface unit 316 comprise transceivers having respective transmitter chains 402 and respective receiver chains 404, it should be appreciated that either or both of the first Ethernet interface unit 304 and the second Ethernet interface unit 316 can comprise either a transmitter chain 402 alone, a receiver chain alone or both.

In operation (Figure 6), data is communicated between the first card 206 and the second card 208, the data being traffic relevant to the functions of the first and second cards 206, 208. The exact nature of this data is not relevant to the present invention and so will not be described further.

The timing source unit 302 of the first card 206 receives the GPS or Stratum-1 reference 300 (Step 600). The first Ethernet interface unit 304 calculates the TSM (Step 602) and an offset (Step 604) using the GPS or Stratum-1 reference, for example, a first timer (not shown) provided by the timing source unit 302 is arranged to count-down to zero every time the TCM is due. Since the GPS or Stratum-1 reference 300 is periodic, for example, every 1s or 125 μs, the value of the timer constitutes the offset. The first Ethernet interface unit 304 then awaits the inter-frame gap 502 between subsequent frames 500 (Step 606). If the inter-frame gap 502 has not occurred, the first Ethernet interface unit 304 determines whether the transmission of timing data is still required (Step 608). If timing data is not required, the first Ethernet interface unit 304 ceases transmitting timing data (Step 610). Otherwise, the first Ethernet interface unit 304 continues to await an inter-frame gap 502 (Step

606). Once an inter-frame gap 502 commences (signified by the presence of the ESD), the first Ethernet interface unit 304 inserts (Step 612) the TSM and the offset into the space constituting the inter-frame gap 502. The first Ethernet interface unit 304 then determines whether further timing data is to be included in subsequent inter-frame gaps 502 (Step 614). If the transmission of timing data is to be continued, the first Ethernet interface unit 304 recalculates the offset (Step 604) and continues by following the procedural steps described above that follow (Steps 606 to 614) the calculation of the offset (Step 604). Otherwise, the insertion of timing data into the inter-frame gap 502 ceases (Step 610).

Referring to Figure 7, the second Ethernet interface unit 316 receives a stream of data (Step 700). The second Ethernet interface unit 316 monitors the stream of data in order to locate (Step 702) the inter-frame gap 502 and determines (Step 704) whether timing data is present in the inter-frame gap 502. If the inter-frame gap 502 does not contain any timing data, the second Ethernet interface unit 316 awaits a subsequent inter-frame gap (Step 702) to determine (Step 704) whether the subsequent inter-frame gap contains timing data. This loop continues until timing data is identified. If, or once, timing data is present in the inter-frame gap 502, the second Ethernet interface unit 316 extracts (Step 706) the timing data during the inter-frame gap and transmits the timing data to the local timing unit 330. The local timing unit 330 then loads the timing data, in this example, the offset into the second timer (not shown) provided by the local timing unit 330, the second timer also being arranged to count down to zero. Consequently, the second timer reaches zero at the same time as the first timer. Hence, the location of the TSM is communicated across the Ethernet link 318 and the timing data has been converted (step 708) into a clock signal for use by the board specific logic 332 and the second processor 320.

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Although the above examples have been described in the context of a 100 Mbps Ethernet, it should be appreciated that the above examples are equally applicable to 1000 base T gigabit Ethernet.

Alternative embodiments of the invention can be implemented as a computer program product for use with a computer system, the computer program product being, for example, a series of computer instructions stored on a tangible data recording medium, such as a diskette, CD-ROM, ROM, or fixed disk, or embodied in a computer data signal, the signal being transmitted over a tangible medium or a wireless medium, for example microwave or infrared. The series of computer instructions can constitute all or part of the functionality described above, and can also be stored in any memory device, volatile or non-volatile, such as semiconductor, magnetic, optical or other memory device.

CLAIMS:

1. A method of communicating timing information in an Ethernet between a first network entity (206) and a second network entity (208) coupled, the method comprising the steps of

communicating (700) a plurality of frames (500) of data between the first network entity (206) and the second network entity (208), at least two of the plurality of frames (500) of data being separated by an inter-frame gap (502), and

communicating timing information in the inter-frame gap (502) between the first network entity (206) and the second network entity (208).

2. A method as claimed in Claim 1, wherein the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

3. A method as claimed in Claim 2, wherein the predetermined amount of the timing signal is a period of the timing signal.

4. A method as claimed in Claim 2, wherein the offset data corresponds to a number of timing units.

5. A method as claimed in Claim 4, wherein the timing units are clock signals.

6. A communications apparatus comprising an Ethernet coupled to a first network entity (206) and a second network entity (208), the first network entity (206) and the second network entity (208) being arranged to communicate a plurality of frames (500) of data therebetw en, at least two of the plurality of frames (500) of data being separated by an inter-frame gap

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(502), wherein the first network entity (206) and the second network entity (208) are adapted to communicate timing information therebetween in the inter-frame gap (502).

7. An apparatus as claimed in Claim 6, wherein the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

8. An apparatus as claimed in Claim 7, wherein the predetermined amount of the timing signal is a period of the timing signal.

9. An apparatus as claimed in Claim 7, wherein the offset data corresponds to a number of timing units.

10. An apparatus as claimed in Claim 9, wherein the timing units are clock signals.

11. A base station comprising the communications apparatus as claimed in any one of Claims 6 to 10.

12. A network entity apparatus (206) for coupling to an Ethernet, the apparatus comprising:

a transmitter (402) coupled to a processing unit (306) and arranged to transmit a plurality of frames (500) of data, at least two of the plurality of frames (500) of data being separated by an inter-frame gap (502), wherein the processing unit (306) is arranged to insert timing information in the inter-frame gap (502) for transmission by the transmitter (402).

13. A network entity apparatus (208) for coupling to an Ethernet, the apparatus comprising:

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a receiver (404) coupled to a processing unit (320) and arranged to receive a plurality of frames (500) of data, at least two of the plurality of frames (500) of data being separated by an inter-frame gap (502), wherein the processing unit (320) is arranged to extract timing information from the inter-frame gap (502).

14. An apparatus as claimed in Claim 12 or 13, wherein the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

15. An apparatus as claimed in Claim 14, wherein the predetermined amount of the timing signal is a period of the timing signal.

16. An apparatus as claimed in Claim 14, wherein the offset data corresponds to a number of timing units.

17. An apparatus as claimed in Claim 16, wherein the timing units are clock signals.

18. A base station comprising the network entity apparatus as claimed in any one of Claims 12 to 17.

19. A communication signal for an Ethernet, the signal corresponding to a first frame (500) of data separated from a second frame of data by an inter-frame gap (502), wherein the inter-frame gap (502) comprises timing information.

20. A signal as claimed in Claim 19, wherein the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

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21. A signal as claimed in Claim 20, wherein the predetermined amount of the timing signal is a period of the timing signal.

22. A signal as claimed in Claim 20, wherein the offset data corresponds to a number of timing units.

23. A signal as claimed in Claim 22, wherein the timing units are clock signals.

24. A computer program element comprising computer program code means to make a computer execute the method Claims 1 to 5.

25. A computer program element as claimed in Claim 24, embodied on or in a computer readable medium.

26. A use for a code set to communicate timing information between a first network entity (206) and a second network entity (208) coupled to an Ethernet, the first network entity (206) and the second network entity (208) being arranged to communicate a plurality of data frames (500) therebetween, at least two of the plurality of data frames (500) being separated by an inter-frame gap (502), wherein at least one symbol of the code set is communicated in the inter-frame gap (502), the at least one symbol corresponding to the timing information.

27. A use as claimed in Claim 26, wherein the at least one symbol of the code set comprises an offset symbol indicative of a point in time corresponding to a predetermined amount of a timing signal.

28. A use as claimed in Claim 27, wherein the timing information comprises offset data indicative of a point in time corresponding to a predetermined amount of a timing signal.

29. A use as claimed in Claim 28, wherein the offset symbol corresponds to a number of timing units.

30. A use as claimed in Claim 29, wherein the timing units are clock signals.

31. A use as claimed in Claim 26, wherein the code set is a 4B5B code set.

32. A use as claimed in Claim 26, wherein the code set is an 8B10B code set.

33. A method of communicating timing information in an Ethernet substantially as hereinbefore described with reference to Figures 6 and 7.

34. A communications apparatus substantially as hereinbefore described with reference to Figures 2 to 5.

35. A network entity substantially as hereinbefore described with reference to Figures 3 to 5.

36. A communication signal for an Ethernet substantially as hereinbefore described with reference to Figure 5.

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Application No:	GB 0019926.5	**Examiner:**	John Betts
Claims searched:	1-36	**Date of search:**	27 March 2001

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Other: On-line: WPI, EPODOC, JAPIO, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

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